NEW MEASURE AGAINST NOISE FROM BRIDGE JOINT

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ABSTRACT

When cars pass bridge joint, a sudden noise occurs. It is difficult to evaluate the noise by equivalent sound level in environmental quality standard, and it severely affects neighbors. Up to the present some measures have been taken to reduce the noise level, such as covering whole girders and filling joint space with elastic material. However, there were problems in construction, maintenance and cost on the methods. In order to overcome the problems, E-NEXCO and Shizuka co., ltd. carried out a joint research.

We selected to use new material, which possesses a high absorbent capability, light in weight but strong enough to be flexible with the movement of bridge. Besides, this material can be easily and economical set under joints. We set it around noise source for absorbing sudden noises.

As a result, we found that the reduction of noise level was approximately 14dB(A) on irregular sudden noises when this material was set around bridge joint. It took very short time period to set the material on site. We believe that this measure will be applicable to similar site conditions.

1. INTRODUCTION

1-1. Japan’s expressway conditions

In Japan, over 50 years ago, before the rapid economic growth, only 17.1% of the primary national expressways as the nation’s major truck roads were paved, and there were many uneven gravel roads. The passage of pedestrians and vehicles was very troublesome across the nation (see Figure 1).


Figure 1. Road conditions in around 1955

However, with the growth of the economy,

automobiles became widespread dramatically, and the number of automobiles owned exceeded 2 million in 1957, indicating the advent of a full-scale motorization. However, Ralph J. Watkins, an economist invited by the Japanese government to construct the Meishin Expressway, wrote in the 1956 report, “The roads of Japan are incredibly bad. No other industrial nation has so completely neglected its highway system.” The Japanese government took the matter seriously and immediately went into action.

Thus, Japan’s expressway improvement picked up a full head of steam, and it greatly contributed to the subsequent rapid economic growth. Since the construction of the Meishin Expressway, networks of roads (some 8,500 km) have so far been constructed and maintained in Japan.

While development was achieved in various industries in the course of the economic growth, environmental pollutions such as air pollution and noise were also caused on roads. However, Japan has dealt with such environmental issues by introducing innovative technology.

1-2. Overview of East Nippon Expressway Company Limited

East Nippon Expressway Company Limited (hereinafter called “E-NEXCO”) constructs and maintains expressways from Tokyo, which is the capital of Japan, to Hokkaido, which is the northernmost of the four main islands of Japan, and the company has so far constructed roads of approximately 380 kilometers and maintains roads of a total of approximately 3,500 kilometers (see Figure 2).

In order to reduce the impact of road traffic noise on roadside areas, E-NEXCO has conducted the construction and maintenance of roads with consideration for the roadside environment. For example, the company’s efforts include installing buffer zones such as noise barriers and green belts and adopting highly-functional pavement that effectively reduces noise.

This report introduces measures against particular traffic noise implemented through active utilization of new techniques, with the aim of maintaining a good roadside environment.

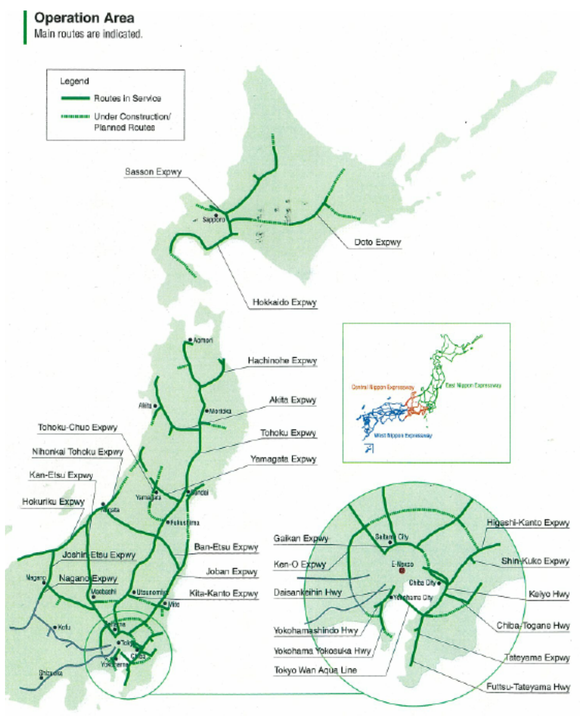


Figure 2. The area covered by E-NEXCO

2. NOISE PROBLEM AND SITE INSPECTION

2-1. Noise problem

The measures were implemented in Nerima, Tokyo, near starting point of the Kan-Etsu Expressway that extends between Tokyo and Niigata. The daily traffic volume exceeds 100,000 vehicles in this section. As shown in Figure 3, the roadside area is a residential area with many crossroads, and the expressway extends in a simple type of elevated structure with steel joints.

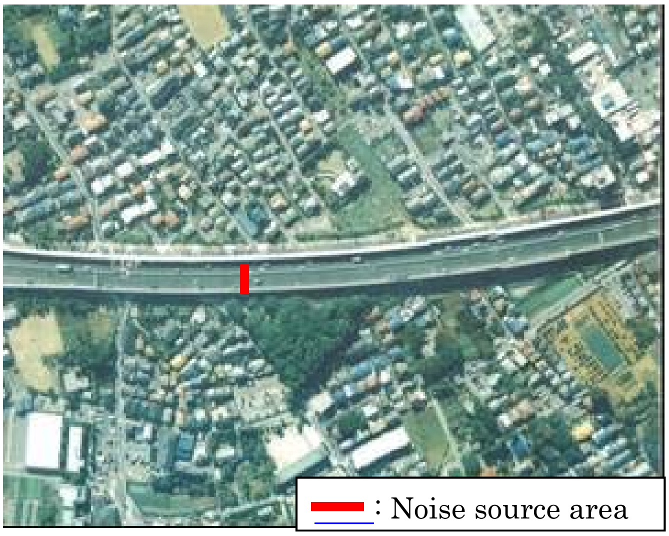


Figure 3. Residential area around the elevated road

Since there were demands for measures against noise from residents in this area, E-NEXCO installed a noise barrier with a height of 6 meters on either side of the expressway (Figure 4). Also, the company has begun to make the bridge's main girder continuous since 2000 to reduce the number of joints. However, as Figures 4 and 5 show the situation, there had been demands from residents in the roadside area for additional measures against day-and-night sudden noises caused from the remaining joint.

Figure 4. Noise source site (outside)

* Noise is caused from the bottom part of the crossbeam

Figure 5. Noise source site (inside)

* Noise is caused from the bottom part of the crossbeam

2-2. Measurement of noise at the site

To grasp how the noises are generated, noises were measured at the site boundary.

Table 1 shows Japan's environmental quality standards, measured values of the noise level at the site, and the traffic flow volume for 24 hours at the site on the measurement date.

Table 1. Results of preliminary noise measurement (site boundary, unit: dB(A)) and total traffic flow volume for 24 hours (unit: vehicles)

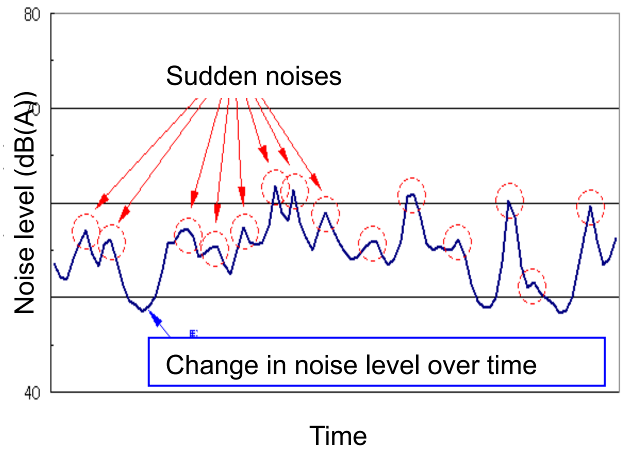
Period of time	Environmental Quality Standards	LAeq	LAmax	Total traffic flow volume 24 hours (Traffic counter data)
Day (6:00-22:00)	70	62	73 – 80	85, 239
Night (22:00-6:00)	65	58	68 - 82	14,010

As shown in Table 1, the measured equivalent continuous A-weighted sound pressure level (LAeq)*[1] meets the environmental quality standards.

The Japanese government stipulates the environmental quality standards as “the standards, the maintenance of which is desirable for the protection of human health and the conservation of the living environment.” The equivalent continuous A-weighted sound pressure level is the average value of energy in a certain period of time. However, since a sudden noise is caused approximately within 0.1 sec., the average value is not affected by such instantaneous large noise. Thus, sudden noises cannot be properly evaluated by the environmental quality standards.

The results of the on-site measurement in Table 1 show that the maximum value was from 68 to 82 dB(A), which was obtained at night when sudden noises from the joint were clearly audible. The energy ratio of LAeq 62 dB(A) and sudden noise 82 dB(A) is 1: 100, which is equal to the difference in noise between an average office room and a noisy factory. Thus, since such sudden occurrence of large noises must cause a large psychological burden, it was assumed that most of the complaints about noise had been made about these sudden noises.

To grasp the characteristics of such sudden noises, noises were again measured immediately under the joint. Approximately 100 sample sudden noises were collected and calculated as shown in reference drawing 1, and the number of occurrences of the sudden noises with respect to the noise level was shown in Fig. 6. As the results show, it was found that the noise level of the sudden noises caused by the bridge joint part was high, between 99 dB(A) and 85 dB(A), and particularly, there were many sudden noises at the level of around 90 dB(A).



Reference drawing 1. Change in noise level over time

*1: As to road traffic noise, “Environmental Quality Standards for Noise” were established under the Noise Control Law. The equivalent continuous A-weighted sound pressure level (LAeq), which is recently widely used in the world as an examination method, is adopted.

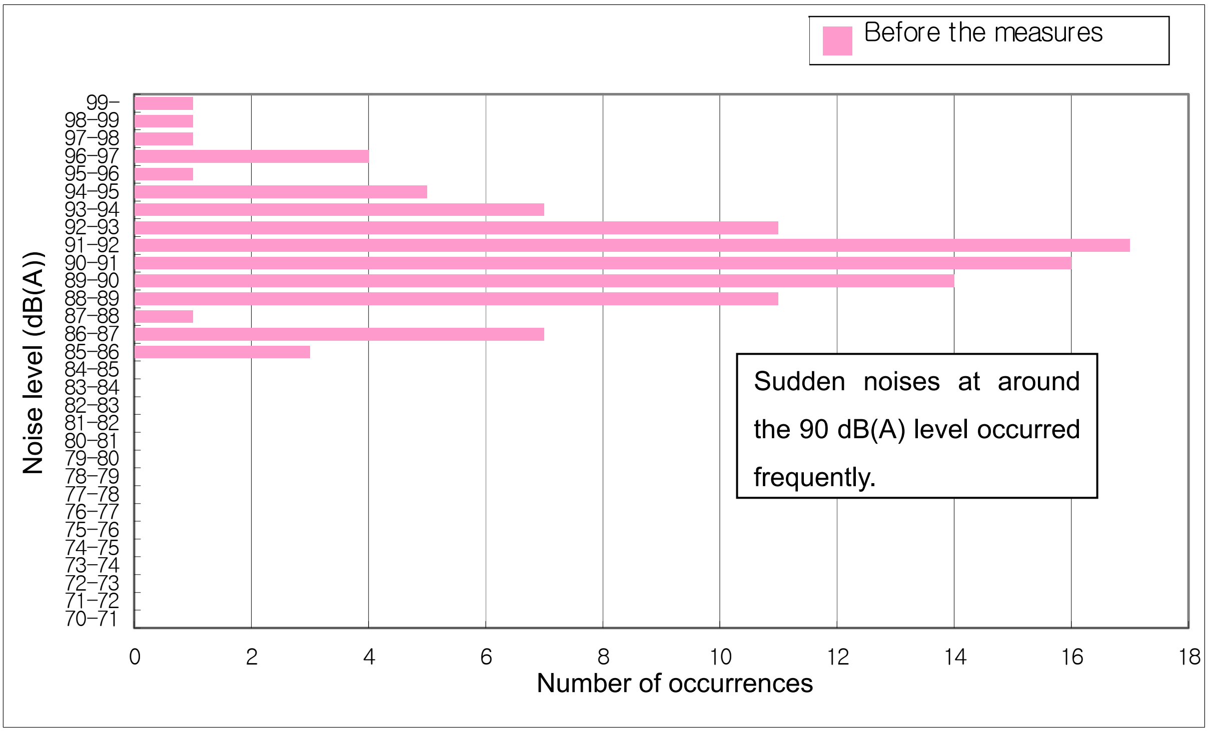


Figure 6. The number of occurrences of the sudden noises with respect to the noise level

Further, the frequency of each of the sudden noises was analyzed, and Fig. 7 shows the average value of the results.

The results of the analysis show that the noise level was as high as over 70 dB(A) particularly in a wide frequency range of 160 to 1,600 Hz.

Thus, measures against sudden noises need to be satisfied the following conditions:

1. To use effective materials for noises with a high frequency
2. To apply effective installation method using the material for reducing sudden noises

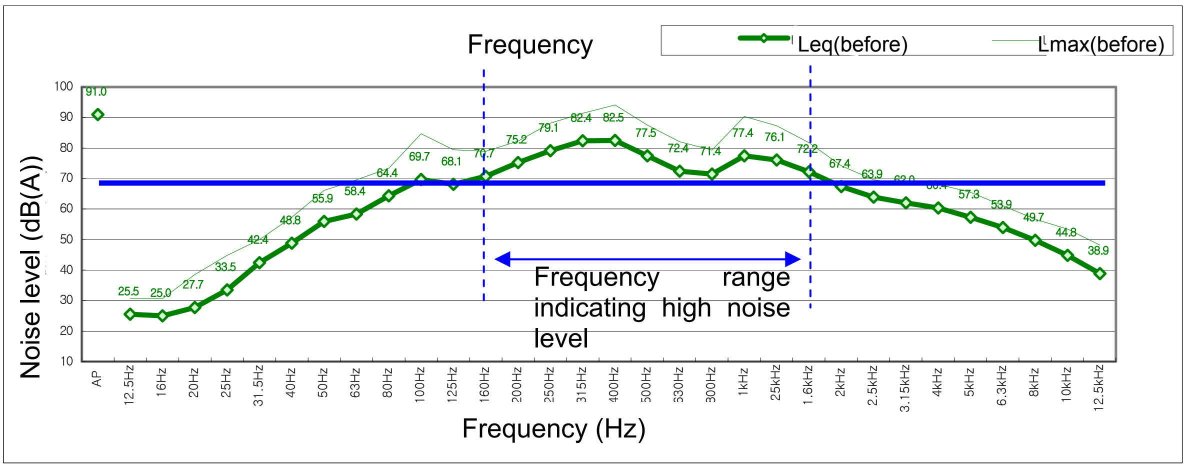


Figure 7. Results of frequency analysis on sudden noises (preliminary measurement)

3. DEVELOPMENT OF NEW TECHNIQUES AND NEW CONSTRUCTION METHOD

E-NEXCO has been actively incorporating products and construction methods developed by other companies with the know-how accumulated through its expressway business, so as to develop and introduce cutting-edge technology.

Shizuka co., ltd., which has been developing sound absorption panels for many years, is one of our partners and suggested use of a light, easy-to-process, rustless sound absorber that exhibits high sound absorption properties in a frequency of over 400 kHz. With the utilization of the properties of this sound absorber, E-NEXCO and Shizuka co., ltd. jointly conducted research and development to produce a product, as measures against noise, which can be easily installed at a narrow and small bridge joint part.

As shown in Figure 8, sudden noises are generated from the bottom surface of the joint as linear sound source. Thus, it was decided that the best way was to cover the bottom surface of the joint with the sound absorber in a box-like shape. Through subsequent research, it was found that an openable bottom surface would enable inspection of the bottom part of the joint even after the installation of the sound absorber (Fig. 9).

Additionally, a laboratory test showed that use of this sound absorber provides a reduction of approximately 30 dB(A), compared with when this sound absorber is not used. Namely, the high sound absorption properties of this sound absorber was confirmed.

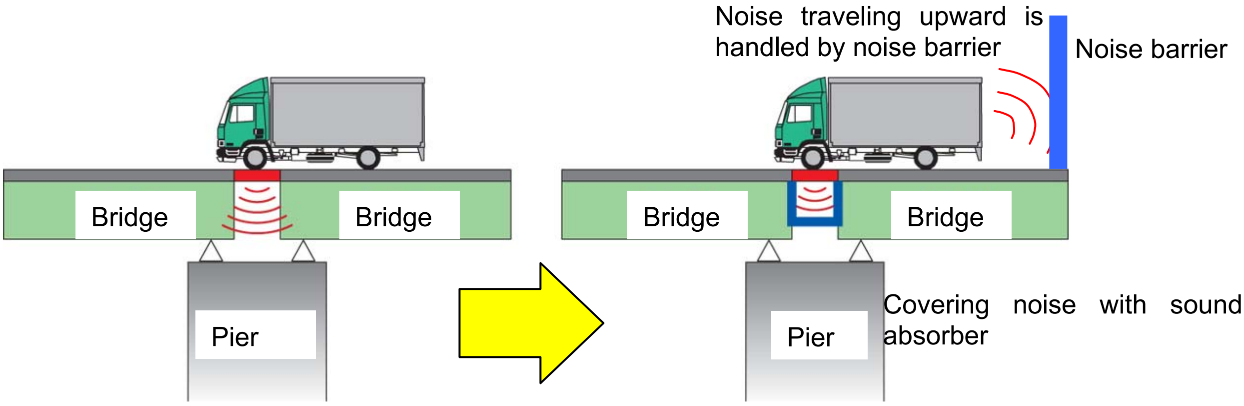


Figure 8. Measure against joint noises

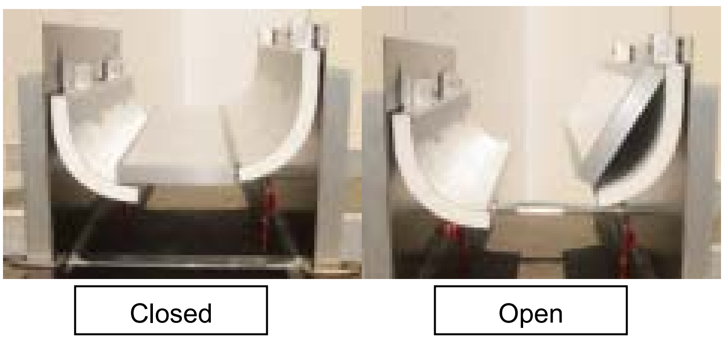


Figure 9. Box-shape sound absorber co-developed by E-NEXCO and Shizuka

However, as shown in Figure 10, while the superstructure of the bridge is a PC pretension girder bridge and crossbeams for securing the main girder are placed at the girder end portion at site where the measures were implemented the site has the very narrow and small structure; for example, the clearance between the top of the pier and the bottom of the crossbeam is approximately 40 cm, the clearance between two of the crossbeams is approximately 10 cm, and the amount of expansion of the bridge is approximately 20 cm (Fig. 11). Thus, in view of the conditions required at the site, an optimum shape for installation needed to be explored.

Figure 10. Situation at the site

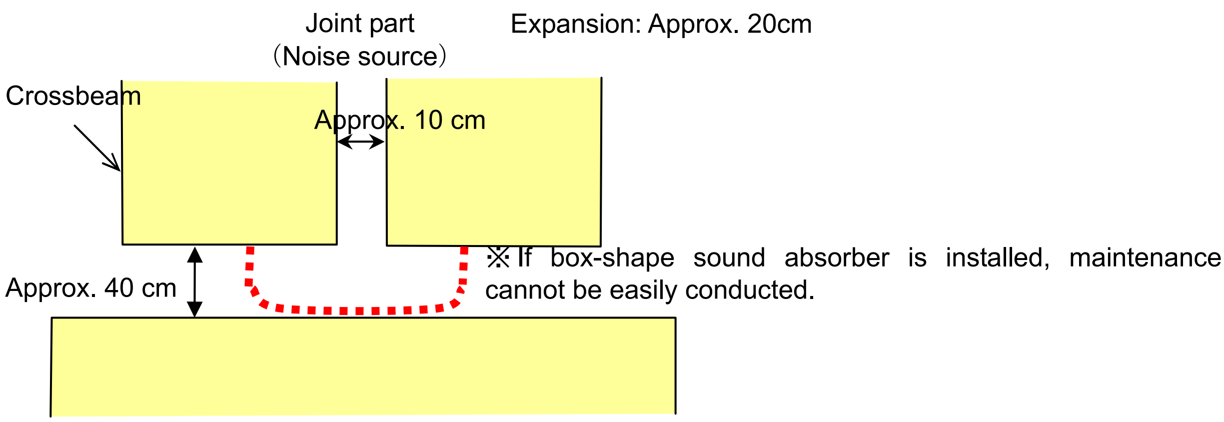


Figure 11. Side view of the installation site

4. EXAMINATION OF DESIGN CONDITIONS

In order to implement the measures at the site, the following conditions were examined:

(1) The product to be developed needs to have a shape that can cover the clearance of approximately 40 cm under the crossbeam.

(2) The amount of expansion of the bridge needs to be followed.

(3) The noise level in the frequency range of 160 to 1,600 Hz needs to be reduced.

(4) Easy inspection after the implementation of the measures needs to be assured.

(5) Sufficient resistance to rain water flowing from the joint part needs to be assured.

(6) Work can be conducted with a mobile lift.

5. MATERIAL AND CONSTRUCTION METHOD

5-1. Characteristics of material

As described above, the material used for the measures was developed by Shizuka co., ltd. An aluminum board with a thickness of 1.2 mm is used as a base, and a honeycomb-structure paper material, whose top surface is impregnated with ceramic material, is filled with phenol foam material having sound absorption properties. An oxidatively-treated aluminum mesh material having air gaps is used as the sound absorption surface. All of these elements are integrally attached to each other, and the product itself has a bending strength (Fig. 12). The characteristics are as follows:

(1) The thickness of the product material is as thin as 34 mm and the weight is as light as 8 kg/m^2.

(2) The material has high sound absorption properties, especially in the frequency range of over 400 Hz.

(3) Aluminum is used for the base material, and thus, the product is sufficiently durable to resist damage from rain water and salt.

(4) The product can be easily processed (cutting and the like) at the factory.

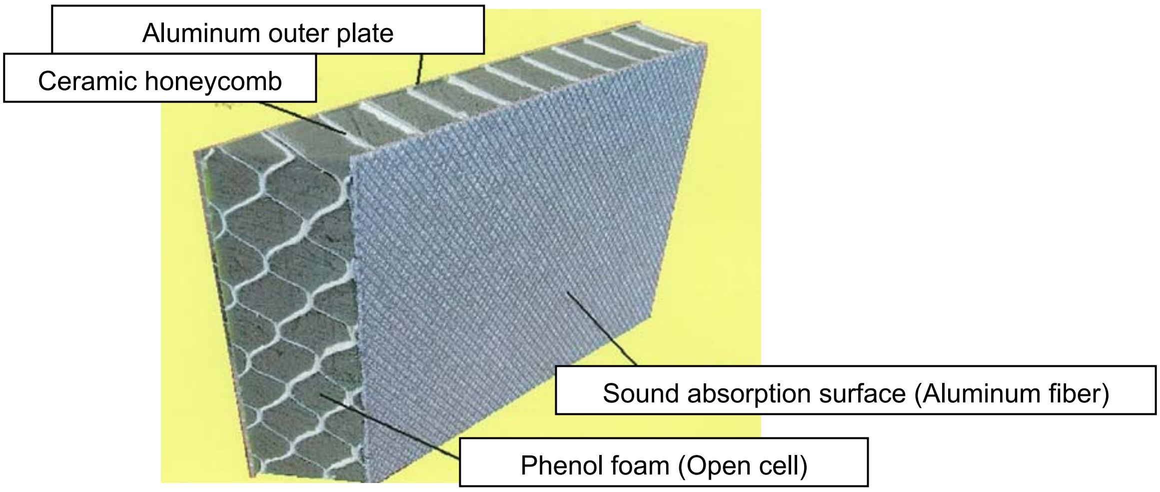


Figure 12. Cross section of sound absorber

5-2. Production and installation of sound absorber

As described in chapters 3 and 4, the site at which the measures were implemented was very narrow and small. However, the sound absorption area could be reserved by enclosing the clearance between the crossbeam, the top surface of the pier and the expansion gap portion of the main girder with the sound absorbers. Regarding the installation of the sound absorbers, there are three possible methods, 1) Installation at crossbeam, 2) Installation at pier. and 3) Installation at crossbeam and pier. Considering bridge contraction due to temperature, we selected 1) installation of crossbeam. Methods 2) and 3) do not allow the bridge contraction. The sound absorbers were attached to the concrete surface of the crossbeam with anchors and adhesive. In this way, they could slide on the top part of the pier (Fig. 13).

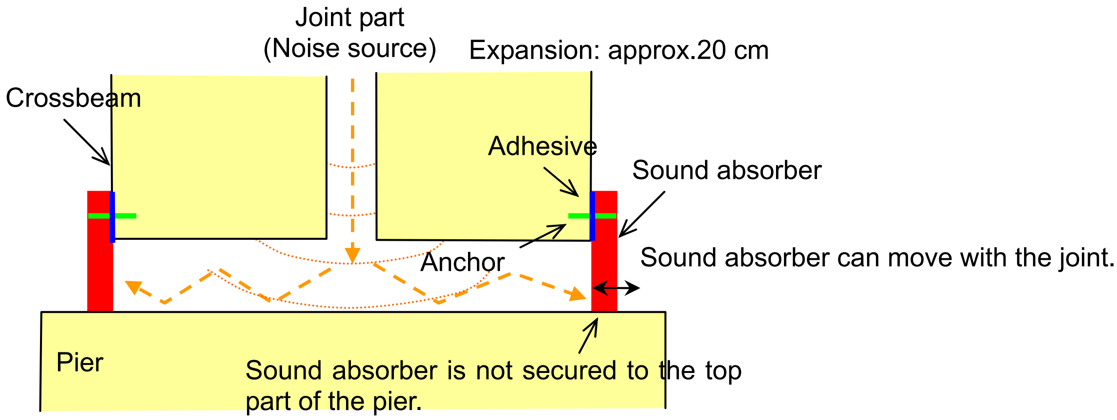


Figure 13. Installation of sound absorber

The procedure for installing the sound absorber only involves (1) measurement of the clearance at the site; (2) creation of a pattern paper; (3) manufacture at the factory; and (4) installation at the site.

Figure 14. Installation of sound absorber

Next, Figure 14 shows the installation of the sound absorber. Since the sound absorber was light, it took only two workers to install the material with the use of a mobile lift and simple tools used for securing the material. The sound absorber can be removed easily for the inspection of the bridge or the like. Also, while we installed the sound absorbers for six traffic lanes x 2 (installed on both sides), which was a total length of approximately 50 m, actual work took only as short as about one day.

Figure 15. Overview of installed sound absorbers

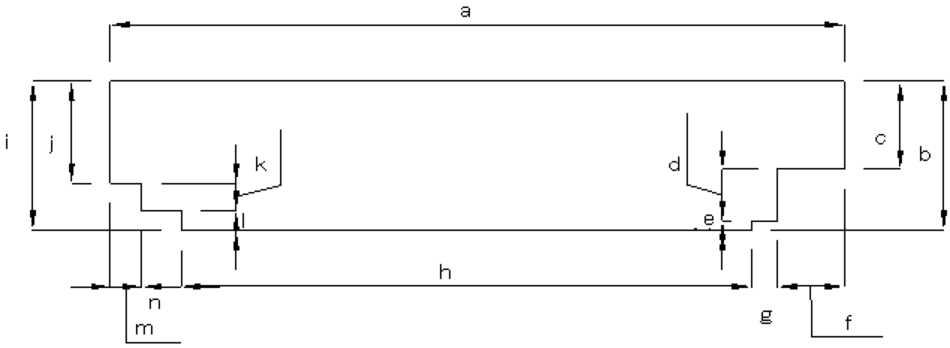


Figure 16. Measurements of sound absorber

6. VERIFICATION OF THE EFFECTS

As in the preliminary measurement, the noise level was measured immediately under the joint part and the results were compared with those of the preliminary measurement. As shown in Fig. 17, the upper noise level 97 to 86 dB(A), which was seen before the measures were implemented, was reduced to 86 to 70 dB(A), and thus, the effects of reducing sudden noises by approximately 14dB(A) were confirmed.

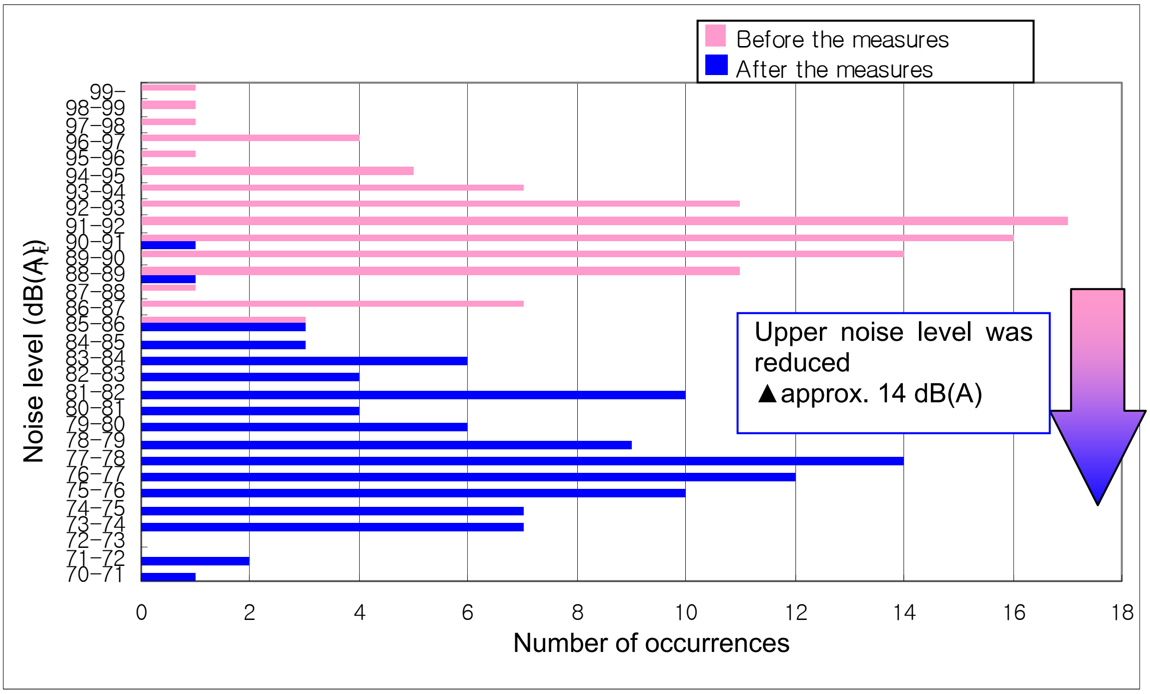


Figure 17. Comparison of the number of occurrences of the sudden noises with respect to the noise level

Also, as to the results of frequency analysis, while the results of the preliminary measurement showed that the noise level was over 70 dB(A) in the frequency range of 160 to 1,600 Hz, the implementation of the measures reduced the noise level below 70 dB(A) at almost all frequencies in the range. A reduction of 9.0 to 16.5 dB(A) was confirmed at each of the frequencies (Fig. 18).

Therefore, it was clearly demonstrated that the product and the method for installing the product in view of the site conditions were effective in reducing the sudden noises.

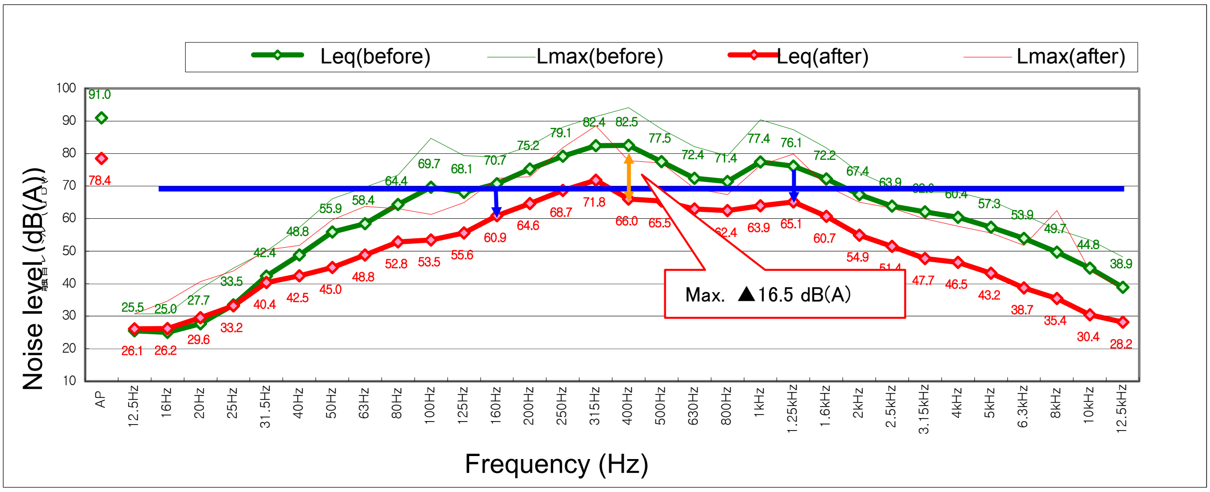


Figure 18. Comparison of the results of frequency analysis on sudden noises

7. CONCLUSION

Even though this is a new approach to reduce noise from bridge joints, we completed it from the planning to setting within relatively short time.

Moreover, although the method to install sound absorbers had not initially fixed, this approach had an advantage that the structure has a flexibility to settle following site situation, and the whole process did not take much time with limited processes as measurement, creation of the mold form, manufacture at the factory and installation at site. Also it was very effective in view of complaints about noise from residents in the roadside area. No complaints about the sudden noises have so far been received since the implementation of the measures.

Elevated bridges have been adopted for many of the expressways in the urban area, and joints are always installed in these bridges. Thus, the problem of noise from such joints has existed since the birth of the first expressway. While it is currently difficult to evaluate the impact of the sudden noises, E-NEXCO, as a road administrator, needs to take measures continuously in various ways and to make consideration for residents in the roadside area.

It would be a great pleasure if this report could be of any help to people in other regions or countries with the same problem.